



Sealed Valve Regulated (SVR) Gelled Electrolyte Lead-Acid Batteries

MK Battery and American Workshop

Introduction

Sealed gel technology (commonly referred to as "gel cell" technology) was developed several years ago. Over the years, the gel battery has evolved and developed into the battery of choice for discriminating system designers, application engineers and sophisticated users.

In 1991, our plant began building gel cell batteries using tried and true technology backed by more than 50 years experience. Our unique computer-aided manufacturing expertise and vertical integration have created a product that is recognized as the **highest quality, longest life gel battery available from any source.**

Applications

Gel cells can be used in virtually any flooded electrolyte wet cell application (in conjunction with well-regulated charging), as well as applications where traditional wet cells cannot be used. Because of their unique features and benefits, gel cells are particularly well suited for:

Deep Cycle, Deep Discharge Applications

- Marine Trolling
- Electric Vehicles
- Portable Power
- Personnel Carriers
- Commercial Deep Cycle Applications
- Electronics
- Wheelchairs
- Floor Scrubbers
- Marine House Power
- RVs
- Sailboats
- Golf Cars

Standby and Emergency Backup Applications

- UPS (Uninterrupted Power Systems)
- Emergency Lighting
- Cable TV
- Computer Backup
- Telephone Switching

Unusual and Demanding Applications

- Race Cars
- Off-road Vehicles
- Marine Starting
- Air-transported Equipment
- Wet Environments
- Diesel & I.C.E. Starting

What is a gel cell?

A gel cell is a lead-acid electric storage battery that:

- is pressurized and sealed using special valves, and therefore **should never be opened**.
- is completely maintenance-free*.
- uses a thixotropic gelled electrolyte.
- uses the "recombination" technique to replace oxygen and hydrogen normally lost in a wet cell (particularly in deep cycle applications).

- is non-spillable, and therefore can be operated in virtually any position. However, installation upside-down is not recommended.

* Connections must be retorqued and the batteries should be cleaned periodically.

How does a gel cell work?

A gel cell is a "recombinant" battery. This means that the oxygen that is normally produced on the positive plate in all lead-acid batteries recombines with the hydrogen given off by the negative plate. The "recombination" of hydrogen and oxygen produces water (H_2O), which replaces the moisture in the battery. Therefore, the battery is maintenance-free, as it never needs watering.

The oxygen is trapped in the cell by special pressurized sealing vents. It travels to the negative plate through tiny fissures or cracks in the gelled electrolyte.

The sealing vent is critical to the performance of the gel cell. The cell must maintain a positive internal pressure. Otherwise the recombination of the gasses will not take place, and the cell will dry out and not perform.

In addition, the valve must safely release any excess pressure that may be produced during overcharging. Otherwise the cell would be irreparably damaged.

It's important to note that a gel cell must never be opened once it leaves the factory. If opened, the cell loses its pressure, and the outside air will "poison" the plates and cause an imbalance that destroys the recombination chemistry.

Hence the name: **Sealed Valve Regulated (SVR) Battery.**

What is the difference between gel cell and "starved electrolyte" batteries?

Both are recombinant batteries; both are sealed valve regulated.

The major difference is that the "starved" or "absorbed electrolyte" battery contains an amount of liquid electrolyte added at the factory that soaks into the special separators. Therefore, it is non-spillable because all the liquid electrolyte is trapped in the sponge-like separator material. There is no "free" electrolyte to spill if tipped or punctured.

Because of this "acid-starved" condition, this type of battery does not normally perform well in heavy, deep discharge applications. The gel cell has more electrolyte available, therefore it is better suited for deep discharge applications and can accept occasional overcharging.

What is the difference between gel cell and traditional wet batteries?

Wet cells do not have special pressurized sealing vents, as they do not work on the recombination principle. They contain liquid electrolyte that can cause corrosion and spill if tipped or punctured. Therefore, they are not air transportable without special containers. They cannot be shipped via UPS or Parcel Post or used near sensitive electronic equipment. They can only be installed "upright."

Wet cells lose capacity and become permanently damaged if:

- left in a discharged condition for any length of time (due to sulfation). This is especially true of antimony and hybrid types.
- continually over-discharged, due to active material shedding. This includes specially designed deep cycle wet cells, but is especially true of automotive types.

Deep cycle antimony wet cells have seven times less shelf life as well.

Our gel cells have triple the deep cycle life of wet cell antimony alloy deep cycle batteries, due to our unique design.

How do gel cells recharge? Are there any special precautions?

While our gel cell will accept a charge extremely well due to its low internal resistance, **any** battery will be damaged by continual under- or overcharging. Capacity is reduced and life is shortened.

Overcharging is especially harmful to gel cells because of their sealed design. Overcharging dries out the electrolyte by driving the oxygen and hydrogen out of the battery through the safety valves. Performance and life are reduced.

If a battery is continually undercharged, a power-robbing layer of sulfate will build up on the positive plate, which acts as a barrier to electron flow. Premature plate shedding can also occur. Performance is reduced and life is shortened.

Therefore, **it is critical that a charger be used that limits voltage to no more than 14.1 volts and no less than 13.8 volts at 68°F.**

Batteries used in float service should be charged at 13.8 volts. For deep cycle service, a maximum voltage of 14.1 should be used. The charger must be temperature corrected to prevent under- or overcharging due to ambient temperature changes. (See Charging Voltage vs. Ambient Temperature chart on page 11.)

Important Charging Instructions

The warranty is void if improperly charged. Use a good constant potential, temperature corrected, voltage-regulated charger.

Charge gel cells to at least 13.8 volts but no more than 14.1 volts at 68°F (20°C). **Constant current chargers should never be used on gel cell batteries.**

Can gel cells be installed in sealed battery boxes?

NO! Never install any type of battery in a completely sealed container. Although the normal gasses (oxygen and hydrogen) produced in a gel cell battery will be recombined as described above, and not escape, **oxygen and hydrogen will escape from the battery in an overcharge condition** (as is typical of any type battery).

For safety's sake, these potentially explosive gasses **must** be allowed to vent to the atmosphere and **must never be trapped in a hermetically sealed battery box or tightly enclosed space!**

Can our gel cell be used as a starting battery as well?

Our gel cell will work in SLI (Starting, Lighting and Ignition) applications providing the voltage is regulated between 13.8 and 14.1 volts at 68°F. Most vehicle's regulators are set higher than 14.1 volts. Therefore, the charging system **must be adjusted** for the battery to recharge properly for best performance and longest life.

What do the ratings and specifications signify for this line?

All ratings are **after 15 cycles** and conform to BCI specifications.

CCA = Cold Cranking Amps at 0°F (-17.8°C)

Cold cranking amps equal the number of amps of current a new, fully charged battery will deliver at 0°F (-17.8°C) for thirty seconds of discharge and maintain at least 1.2 volts per cell (7.2 volts for a 12-volt battery).

CA = Cranking Amps at 32°F (0°C)

Same as above, tested at 32°F (0°C). (Note: All cranking ratings are guidelines. Gel batteries are designed for cycling foremost.)

RC = Reserve Capacity at 80°F (27°C)

The reserve capacity is the time in minutes that a new, fully charged battery can be continuously discharged at 25 amps of current and maintain at least 1.75 volts per cell (10.5 volts for a 12-volt battery).

Minutes discharged at 50, 25, 15, 8 and 5 Amps

Minutes discharged is the time in minutes that a new, fully charged battery will deliver at various amps of current and maintain at least 1.75 volts per cell. These are nominal or average ratings.

Ampere Hour Capacity at 20, 6, 3 and 1 Hour Rates

Ampere hour capacity is a unit of measure that is calculated by multiplying the current in amperes (amps) by the time in hours of discharge to 1.75 volts per cell. (These are nominal or average ratings.)

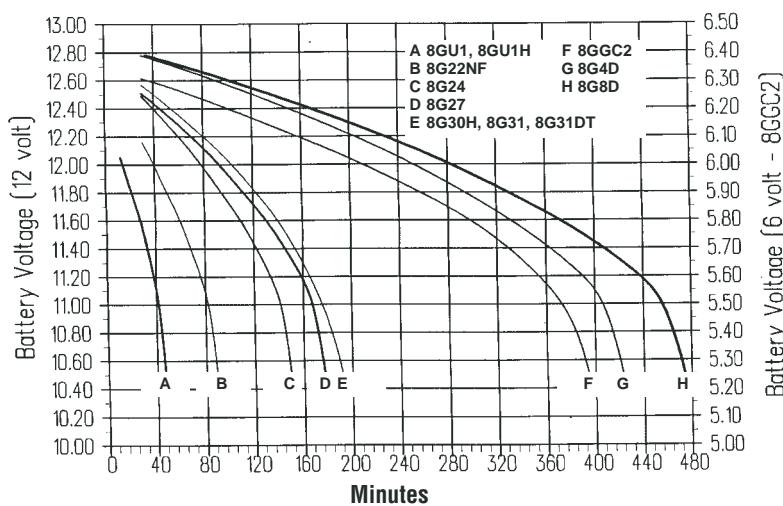
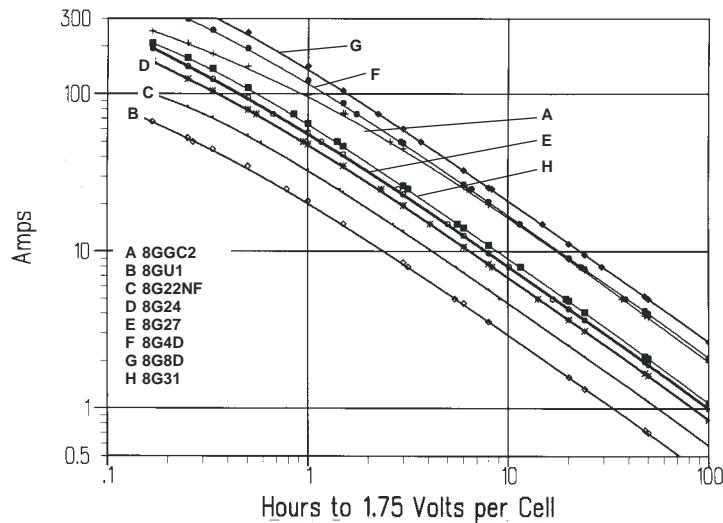
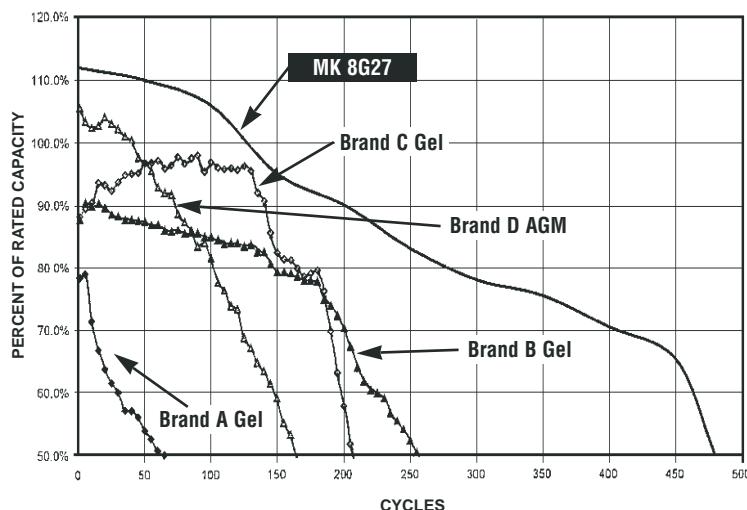
EXAMPLE

10 amps for 20 hr. (10 x 20) = 200 Ah @ 20 hr. rate
8 amps for 3 hr. (8 x 3) = 24 Ah @ 3 hr. rate
30 amps for 1 hr. (30 x 1) = 30 Ah @ 1 hr. rate

Therefore, if you have an application that requires a draw of 17 amps for 3 hours, you would need a 51 Ah battery (@ 3 hr. rate)...(17 x 3 = 51).

However, the 51 amp hours delivered is 100% of the capacity of this 51 Ah battery.

Most system designs will specify a battery that will deliver a minimum of twice the power required. This means the battery will discharge to 50% of its capacity. Using a 50% depth of discharge (versus 80% or 100%) will dramatically extend the life of any battery. Therefore, when helping to specify a battery for a system, choose a battery with **twice** the capacity required for best performance. If 50 Ah is required, specify at least a 100 Ah battery.



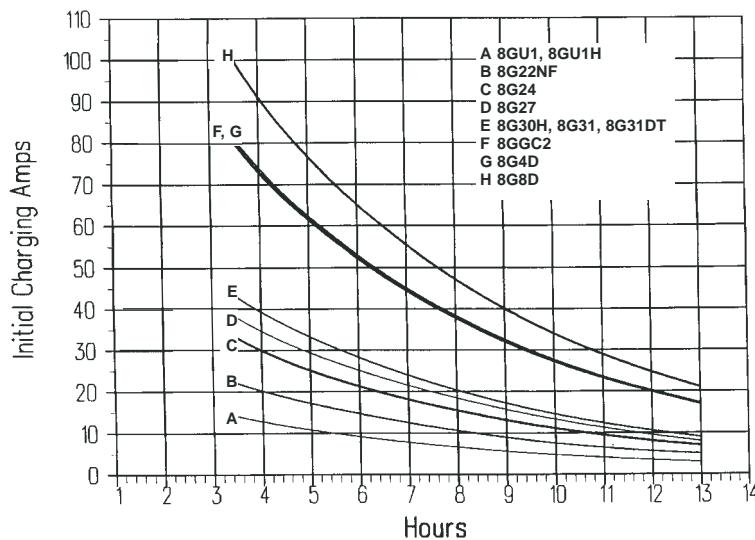


CHART D Charging Hours vs. Initial Charge Amps

Charging at 2.3 Volts Per Cell

This chart shows how many amps of charge it would take to recharge a gel cell from 100% discharge to 90% full charge at 2.3 volts per cell at 68°F.

For example, an 8G8D would take 3½ hours at 100 amps, 6 hours at 65 amps or 13 hours at 20 amps of charging current.

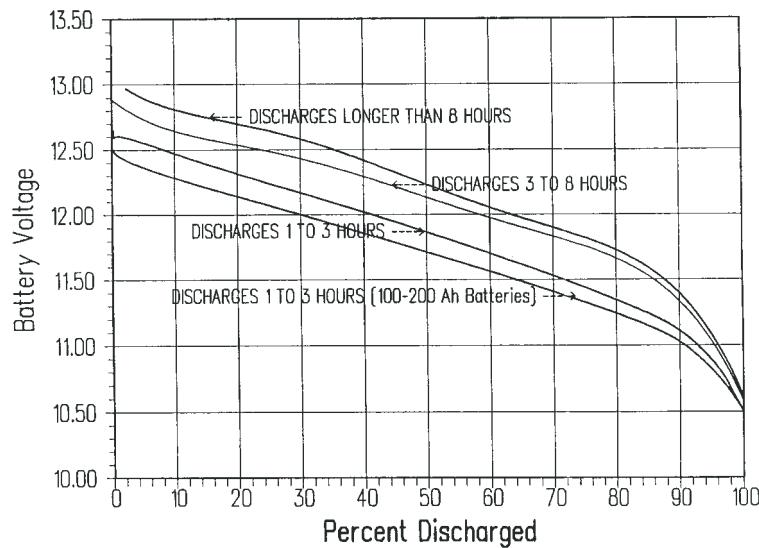


CHART E Gel Battery Capacity Voltage vs. Percent Discharged

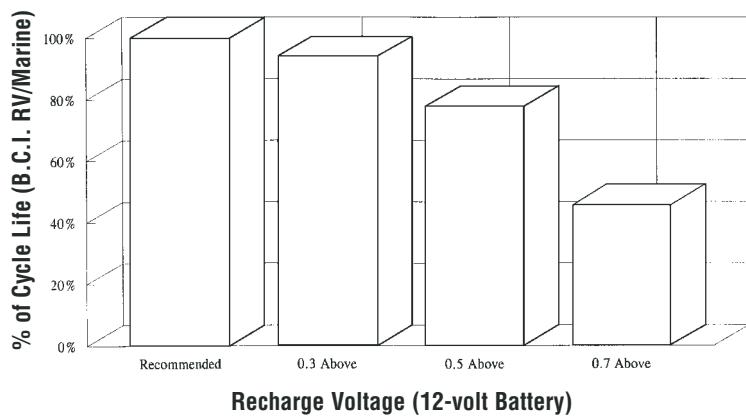


CHART F Percent Cycle Life vs. Recharge Voltage

This chart shows the effect of overcharging a gel cell battery. (e.g.: Consistently charging at 0.7 volts above the recommended level reduces life by almost 60%!)

What are the features and benefits that make MK Battery's gel cell unique?

MK Expertise

We build gel batteries to the highest standards. Our method features improved process controls using state-of-the art computers and the latest manufacturing technology and equipment. Therefore, the gel cells produced by us consistently meet the highest quality performance and life standards.

Spillproof and Leakproof

A major advantage of gel cells is their spillproof and leakproof feature. However, all gel cells are not created equal in their degree of non-spillability. Some gels do not set properly; they remain liquid and can leak or spill.

However, our exclusive thixotropic gel is formulated, mixed and controlled to assure proper "set" in every single battery. Our computer-controlled gel mixing and filling equipment ensures homogenization of the mix.

This assures a gel cell battery that will not spill or leak. This feature allows our gel cell to be operated in virtually any position. However, we do not recommend an upside-down orientation. Any gel battery permanently installed on its side may lose about 10% capacity.

Ultrapremium Sealing Valve

A critical feature of any SVR battery, gelled or absorbed, is the quality of the sealing valve. Not only must the valve keep the cell pressurized and safely release excessive pressure and gas due to overcharging, but it must also keep the cell from being contaminated by the atmosphere. Oxygen contamination will quickly discharge a gel cell and destroy the battery.

Our valves are UL recognized and 100% tested after manufacturing. Then they are tested again after installation on each battery. The benefit is **reliable performance and long life**.

Exclusive Gel Formula

The gelled electrolyte is another critical element in this type of battery. Our gelled electrolyte contains sulfuric acid, fumed silica, pure demineralized and deionized water, and a phosphoric acid additive. The phosphoric acid is a key reason that our batteries deliver **4 to 10 times longer cycle life** than leading gel competitors and 3 times longer cycle life than traditional wet cells.

Deep Discharge Protection

Our gel battery design does not allow self-destructive deep discharging. This prevents the battery from "going into reverse," causing life shortening plate shedding. Therefore, our "special limiting" design **dramatically extends cycle life**: 4 times more than other gel cells and 10 times more than conventional wet cells. The benefit is lower battery replacement cost.

Exclusive Computerized Gel Mixing

Proper gel mixing is critical to life and performance. Inconsistency in mixing means inconsistent reliability. We have designed and built the newest, state-of-the-art gel battery manufacturing facility in the world. An example is our proprietary computerized gel mixing operation.

Our exclusive formula is mixed using computer control in every stage of the process. **Computer control delivers superior consistency for gel cell performance that is unequaled.**

Our temperature-controlled process and specially designed equipment assure a homogenous gel. It is important to note that our equipment was designed by our engineers specifically for gel mixing...even down to the contour of the tank bottoms and feed pipe locations. **No other battery manufacturer has comparable equipment.**

Multi-Staged Filling/Vacuuming Operation

Most other manufacturers fill their gel cells in a one step process, vibrating the battery with hopes of releasing most of the air pockets. This system is less than perfect and leaves voids or air pockets at the critical gel-to-plate interface. These voids are non-reactive and reduce overall battery performance.

Our process fills and vacuums each cell several times. This multi-step process assures complete evacuation of air and **complete gel-to-plate interface**. Our computerized process also weighs every battery before and after filling as a check for proper gel levels. The benefit is **more power-per-pound of battery**.

Tank Formed Plates

We are the **only** domestic battery manufacturer that uses tank formulation to activate the battery plates. This process **guarantees a fully formed and voltage matched plate**. The extra handling of the plates provides an additional inspection step in the process to verify plate quality.

Ultrapremium, Glass Mat, Dual Insulating Separators

Another critical component is the separator, which insulates the positive from the negative plate. The separator must allow maximum electron flow between the plates for maximum performance. Separator failure is a leading cause of warranty claims and customer dissatisfaction.

We use **ultrapremium grade separators** in our gel cells. We believe that this expense (which is 5 to 6 times higher than other types) is worth the benefits of extended life and performance:

- The fiberglass mats imbed themselves into the surface of the plates, acting like reinforcing rods in concrete. This extra reinforcement locks the active material onto the plate for longer life and extended performance.
- The ultra-clean separators have no oil contamination or other impurities. Therefore, **resistance is low and battery performance is high**.
- Excellent porosity allows maximum electron flow, which means **more power-per-pound**.
- Superior resistance to oxidation dramatically reduces separator failure, which **extends life**.
- Our separators are **especially suited for gel batteries**, while others are using separators designed for wet cell automotive batteries.

Exclusive Thru-Partition Weld Seals

One of the causes of self-discharge in batteries is the minute electrical currents that flow between each cell through the partition at the weld area. These currents accelerate the discharge of batteries not in use.

We block these currents by using an **exclusive weld seal** or gasket. This feature **dramatically reduces self-discharge** to less than 3% per month: the lowest self-discharge rate of any battery manufacturer and seven times lower than many conventional batteries!

Exclusive Patented Calcium/Copper Lead Alloy Grids

This exclusive alloy provides **longer shelf life, more power-per-pound and superior corrosion resistance**. By using special grain refiners, we can **dramatically improve performance and life**.

Heavy-Duty Motive Power Style Grid Design

While other manufacturers cut costs by using automotive style grids, we use a high-performance deep cycle gel cell grid. This heavy-duty grid design is similar to the grid in a motive power battery.

The hefty "power rods" designed into our grids not only lock the active material onto the grid, but also act as "bus bars" to collect and direct the energy to the terminals. The benefit is **more power-per-pound** of battery for your equipment and **longer battery life**.

Multiple Plate Lug Milling

Shiny, well milled plate lugs are critical to our superior cast-on-strap quality. Each of our plate lugs is automatically milled **to assure the highest quality** strap with no loose or dropped plates. Our lugs are then fluxed and tinned automatically for an **additional assurance of quality**.

Heavier Plate Straps

We use an **exclusive** lead/tin alloy in a unique multi-staged cast-on-strap operation. The result is heavier straps with **outstanding lug-to-strap knit**. This eliminates dropped and loose plates, thereby **improving performance and life**.

Polyester Element Wrap

Another cause of deep-cycle battery failure is "mossing." This phenomenon occurs late in a battery's life, as the positive active material actually grows around the edge of the separator and eventually "shorts" against the negative plate. This ends the battery's service life.

To prevent life-shortening mossing, we use a **special polyester fiber sheet** that is wrapped around the edge of each element, similar to the wrap in an industrial battery. The result is **longer service life**.

Exclusive Forged Posts and Bushings

"Black" posts and oxygen-contaminated batteries are often due to porous lead terminal posts. A battery can lose its critical pressure through tiny pores and fissures in the battery terminals. Pressure loss is harmful to the battery and is evident by black posts, which are caused by sulfuric acid fumes escaping from the battery through and around the lead posts and bushings. These fumes can cause corrosion and can damage sensitive electronic equipment.

These pores and fissures are caused by the industry's method of casting posts and bushings. This method produces tiny air pockets and paths which allow corrosive gas to escape, causing life shortening depressurization, cell dry-out and corrosion damage.

To eliminate this problem, **we use forged terminal posts and bushings**, which are completely solid with absolutely **no porosity**. The benefit is **longer life**, better performance and **no leakage of corrosive gas**...especially important when installed in or near sensitive electronic equipment.

Acid Stratification Prevention

Acid stratification can occur in stationary and standby applications in conventional wet cells. The lighter discharged acid rises to the top of the cell, and the heavier charged electrolyte sinks to the bottom. Therefore, the upper portion of the cell is discharged and begins to sulfate, and the lower portion begins to corrode prematurely. Life and performance suffer.

Because our electrolyte is immobilized, it cannot stratify. Therefore, **no high-voltage equalizing charge is necessary**. Simply recharge at the standard 13.8 to 14.1 voltage setting. This means **longer life and consistent performance** in stationary and standby applications.

Convenient Carrying Handles

Carrying handles are included on our 8GU1H, 8G24, 8G27, 8G30H, 8G31DT, 8G31, 8G4D and 8G8D models, unlike other gel cells. **This feature makes carrying, installation and removal easier, more convenient and less time consuming**.

Dozens of Terminal Options Available

Our batteries are delivered with the most popular type of terminal. On a special order basis, however, **many terminal options are available**. This gives you total flexibility to specify the **proper terminal for your application**... without making compromises.

Proprietary Case and Cover

We design and mold our own rugged polypropylene cases and covers in our on-site, state-of-the-art plastics molding facility. This provides **ultimate control** of our high performance designs, quality and delivery to our manufacturing plant, **assuring you the highest quality** battery and most reliable service.

Environment and Worker Protection

It's nice to know that every possible safeguard was designed into our process to **protect our co-workers and the environment**... special safeguards that are exclusive to our plant. One benefit is assurance of a consistent source for batteries without fear of governmental interference or delays.

Over 250 Quality Assurance Checks

Hundreds of quality checks are performed to assure total confidence in the performance and life of our batteries.

For example:

- **100% Cycling.** After initial charging, **every battery is completely discharged and then recharged** at the factory. This allows us to check the performance of the battery and give it a second charge that **equalizes the cells for improved performance and longer life.**
- It's interesting to note that, as a cost-saving measure, we use the current generated during the initial discharge to recharge other batteries in this computer-controlled process.
- **Extended Shelf Stand Test.** Before shipment, every battery is required to stand for a designated period of time. Beginning and ending voltages are compared. This **extra quality assurance step** verifies that the critical pressure control valve is functioning properly.
- **Filling Weight Control.** During this computerized process, batteries are weighed before and after filling. This **assures that the exact amount of gel** is in each battery.
- **Multi-Staged Filling and Vacuuming Process.** Every battery is filled and vacuumed several times during this computerized process. Multi-staged vacuuming **assures complete gel-to-plate interface**, with no power-robbing air pockets.
- **Computerized Polarity Check.** Every battery is checked by computer for proper polarity.
- **Formed Element Inspection.** Elements are assembled and **charged outside the battery container** in a computerized forming and drying process. This allows visual inspection of every grid, plate, separator and formed element before being sealed inside the battery, assuring perfect cell elements with longest life and highest performance.
- **Tank Formed Plates.** Voltage matched plates are critical in standby applications. Forming each plate individually, outside the battery assures the **highest quality**, best matched plates in the industry.

State-of-the-Art Technology

Within our multi-million dollar gel cell production facility, we have incorporated **state-of-the-art manufacturing processes** that are unmatched by any other battery manufacturer. This major addition allows us to build the **most modern and reliable gel cell battery in the industry.**

How do MK's battery features compare with other types of batteries?

FEATURE	MK GEL CELLS	OTHER GEL CELLS	ALL STARVED ELECTROLYTE	ALL WET CELLS
1. MK Expertise	YES	NO	MK ONLY	NO
2. Spillproof and Leakproof	YES	YES	YES	NO
3. Sealed Valve Regulated	YES	YES	YES	NO
4. Ultra-Premium Sealing Valve	YES	NO	MK ONLY	NO
5. Exclusive Gel Formula	YES	NO	NO	NO
6. Deep Discharge Protection	YES	YES	YES	NO
7. Exclusive Computerized Gel Mixing	YES	NO	NO	NO
8. Tank Formed Plates	YES	NO	MK ONLY	NO
9. Multi-Staged Gel Filling/Vacuuming	YES	NO	NO	NO
10. Ultra-Premium Glass-Mat Dual Insulating Separators	YES	NO	NO	NO
11. Exclusive Thru-Partition Weld Seals	YES	NO	MK ONLY	NO
12. Exclusive Patented Calcium/Copper Lead Alloy Grids	YES	NO	MK ONLY	NO
13. Heavy-Duty Motive Power Style Grids	YES	NO	MK ONLY	NO
14. Grid Lug Milling, Brushing and Fluxing	YES	?	MK ONLY	NO
15. Heavy-Duty Special Alloy Plate Straps	YES	NO	MK ONLY	NO
16. Special Polyester "Moss Guard" Element Wrap	YES	NO	NO	NO
17. Forged Posts and Bushings	YES	NO	MK ONLYY	NO
18. Acid Stratification Prevention	YES	YES	YES	NO
19. Carrying Handles	YES	?	LIMITED	LIMITED
20. Dozens of Terminal Options	YES	?	MK ONLY	NO
21. Highest Cycle Life	YES	NO	NO	NO
22. Highest Performance	YES	NO	NO	N.A.
23. Shelf Stand Test	YES	?	NO	NO
24. 100% Discharge and Equalizing Recharge	YES	?	NO	NO
25. 250+ Quality Assurance Checks w/ ISO 9001 Certification	YES	?	MK ONLY	NO
26. State-of-the-Art Technology & Facility	YES	NO	MK ONLY	MK ONLY



Answers to the Most Frequently Asked Questions

NOTE: Before reviewing this section, be sure you understand the difference between gel SVR and absorbed SVR batteries.

How do we justify the premium price of gel cell batteries to those unfamiliar with this type of battery?

Simply review the advantages, features and benefits, performance, and **impressive life cycle results**. Based upon this and the **lowest cost-per-month or duty cycle** you and/or your customer should have no trouble choosing this battery.

However, please remember that these batteries are not for everyone or every application. And always be aware of the charging considerations. (See pages 11 & 12.)

What are the advantages and disadvantages of the different types of battery designs?

Gelled Electrolyte Advantages:

- Totally maintenance-free
- Spillproof/leakproof
- Superior deep cycle life
- Very low to no gassing (unless overcharged)
- Compatible with sensitive electronic equipment
- Superior shelf life
- Superior rechargeability (from 10.5 volts to 90% in 3½ hours)
- No recharge current limitation @ 13.8 volts
- Rugged and vibration-resistant
- Very safe at sea with no chlorine gas in bilge (due to sulfuric acid and salt water mixing)
- Most versatile: Starting, Deep Cycle, Stationary
- Operates in wet environments...even under 30 feet of water
- Will not freeze to -20°F/-30°C (if fully charged)
- Lowest cost-per-month (cost ÷ months of life)
- Lowest cost-per-cycle (cost ÷ life cycles)

Gelled Electrolyte Disadvantages:

- Higher initial cost
- Water cannot be replaced if continually overcharged
- Automatic temperature-sensing, voltage-regulated chargers **must** be used
- Charge voltage **must** be limited to extend life (13.8 to 14.1 volts maximum at 68°F)
- Heavier weight

Absorbed Electrolyte Advantages:

- Totally maintenance-free
- Spillproof/leakproof
- Installs upright or on side
- Lower cost than gel cell batteries
- Compatible with sensitive electronic equipment
- Very low to no gassing (unless overcharged)
- Excellent for starting and stationary applications
- Superior for shorter duration/higher discharges
- Air transportable
- No corrosion

Absorbed Electrolyte Disadvantages:

- Shorter cycle life than gel or flooded in deep cycle applications
- Automatic temperature-sensing, voltage-regulated chargers must be used
- Water cannot be replaced if continually overcharged
- Charge voltage **must** be limited (14.4 to 14.6 volts maximum at 68°F)

Flooded Electrolyte Advantages:

- Lowest initial cost
- Water can be added (if accessible)
- Excellent for starting applications
- Accepts higher recharge voltages
- Certain designs are good for deep cycle applications
- Replacements readily available
- Higher cranking amps

Flooded Electrolyte Disadvantages:

- Spillable
- Shorter shelf life than gel
- Cannot be installed near sensitive electronic equipment
- Watering required (if accessible)
- Operates upright only
- Shorter cycle life than gel

Why can't SVR batteries be opened?

SVR (Sealed Valve Regulated), sometimes called SLA (Sealed Lead-Acid), work on the recombination principle. This means that during charging, the hydrogen produced on the negative plate recombines with the oxygen produced on the positive plate to form H₂O or water. This water replaces the moisture in the gel or absorbed mat separators. To work properly, this recombination process must take place with positive internal pressure.

If an SVR battery is overcharged, the hydrogen and oxygen will be produced faster than they can recombine and will be driven out of the cell and lost to the atmosphere. The gel or absorbed separators dry out and the battery prematurely fails.

If an SVR battery is opened, the cell loses its pressure and the negative plate becomes contaminated with excess oxygen, which damages the battery. In addition, when the valves are replaced, they may leak which will damage the battery.

If calcium grids don't do well in flooded deep cycle applications, how can East Penn use calcium grids in gel cells for deep cycle applications?

Flooded calcium is a very efficient, low resistance battery. Therefore, when deeply discharged, the plates release all their available power, causing plate shedding and active material fall-out. In contrast, with flooded antimony batteries, the antimony helps lock the active material onto the grid. Therefore, the plate does not shed as easily, which extends the deep cycle life of the battery when compared to flooded calcium.

Gelled calcium (**Our exclusive patented alloy**) is also very efficient with low resistance. However, when deeply discharged, the electrolyte is used before the plates are totally discharged because the battery is acid-limited. This feature:

- limits the discharge the plates can deliver.
- protects the plates from shedding due to deep discharge.
- extends the life of the battery.

Why do our gel cells have a longer cycle life than others?

Some of the major features that contribute to long cycle life are:

- Our patented calcium/copper grid alloy **delivers superior performance** due to the purity of the lead. Copper is added as a "grain refiner." This means that the microscopic grains in our lead grids are odd-shaped, so they retard corrosion and **extend the life** of our grid.
- Our **thicker grids** have more corrosion resistance than thinner grids.
- Our gel cells are protected against deep discharge because they are **acid-limited**. This means that the battery uses the power in the acid before it uses the power in the plates. Therefore, the **plates are never subjected to destructive deep discharges**.
- With proper temperature-sensing, voltage-regulated charging (between 13.8–14.1 volts at 68°F) the gel cell **never runs out of water**.
- Our ultra-premium, **glass-mat**, dual-insulating separators will not break down in service. The glass mat imbeds itself into the plate, which **retards life-shortening shedding**.
- Our polyester element wrap **retards "mossing"** or active material growth that causes short circuits.
- Over **250 quality control checks** assure superior performance and long battery life.

Why do our gel cells have longer shelf life?

Our calcium/copper lead alloy premium separators and demineralized gel are **ultra-pure**. Impurities in the lead alloy, separators and electrolyte cause tiny currents inside a cell which eventually discharge the battery and shorten its shelf life. **The purer the components, the longer the shelf life.** No one can match MK's purity!

Our exclusive "**weld seal gasket**" blocks the minute cell-to-cell currents that cause self-discharge. The better the weld seal, the longer the shelf life. Weld seals are **exclusive** to MK gel cell batteries.

Does the depth of discharge affect cycle life?

Yes! The harder any battery has to work, the sooner it will fail.

Typical* Gel Cell Cycling Ability vs. Depth of Discharge

Capacity Withdrawn	Typical Life Cycles
100%	500
75%	750
50%	1100
25%	2500
10%	6000

As you can see, **the shallower the average discharge, the longer the life.** This is why it's important to size a battery system to deliver at least twice the average power required.

* You may experience longer or shorter life based upon application, charging regimen, temperature, rest periods, etc.

Why can't our gel cell be discharged too low?

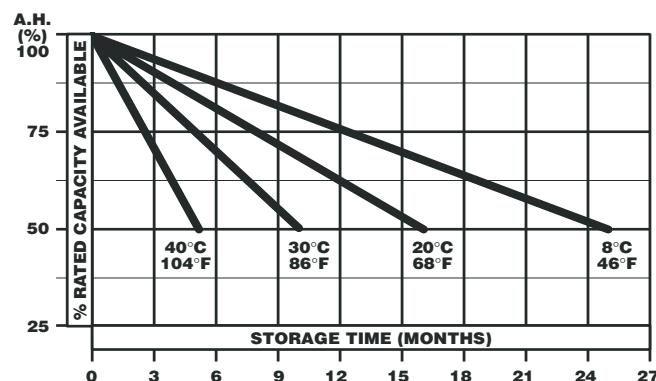
Our gel cells are designed to be "**acid-limited**." This means that the power (sulfate) in the acid is used before the power in the plates. This design protects the plates from ultra-deep discharges. Ultra-deep discharging is what causes life-shortening plate shedding and accelerated positive grid corrosion which destroys a battery.

Why does temperature have such a dramatic effect on batteries?

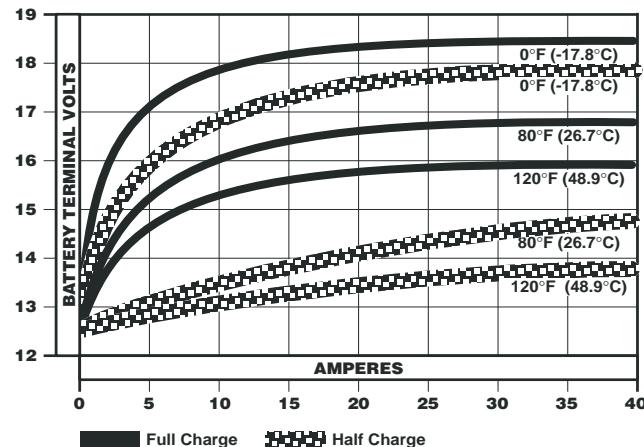
Temperature is a major factor in battery performance, shelf life, charging and voltage control. At higher temperatures there is dramatically more chemical activity inside a battery than at lower temperatures because the ions and electrons move faster in heat than in cold.

The following charts graphically illustrate this fact.

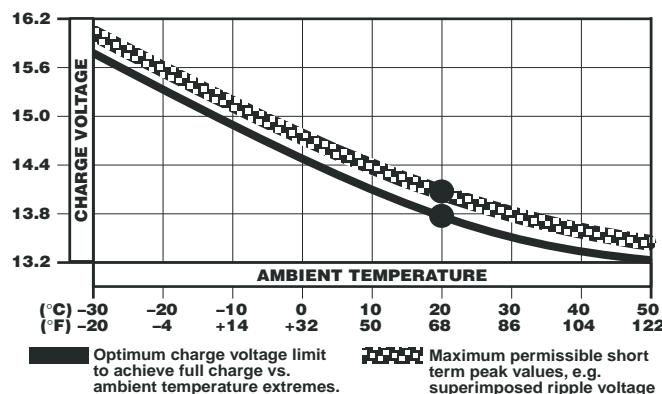
Self-Discharge of Gel Cell Batteries at Different Temperatures



Effect of Temperature on Recharge Voltage



Charging Voltage vs. Ambient Temperature 12-Volt Gel Cell Batteries



Gel Charge and Float Voltages at Various Temperature Ranges

Temp. °F	Charge		Float		Temp. °C
	Optimum	Maximum	Optimum	Maximum	
≥ 120	13.00	13.30	12.80	13.00	≥ 49
110 – 119	13.20	13.50	12.90	13.20	44 – 48
100 – 109	13.30	13.60	13.00	13.30	38 – 43
90 – 99	13.40	13.70	13.10	13.40	32 – 37
80 – 89	13.50	13.80	13.20	13.50	27 – 31
70 – 79	13.70	14.00	13.40	13.70	21 – 26
60 – 69	13.85	14.15	13.55	13.85	16 – 20
50 – 59	14.00	14.30	13.70	14.00	10 – 15
40 – 49	14.20	14.50	13.90	14.20	5 – 9
≤ 39	14.50	14.80	14.20	14.50	≤ 4

What is acid stratification? How do our gel cells prevent it?

Gelled electrolyte is an immobilized electrolyte. When liquid electrolyte or acid stratifies, the heavier charged ions actually sink to the bottom of the cell, leaving discharged acid or water at the top. This allows the top of the plates to oxidize and corrode reducing performance and shortening life. The bottoms of the plates also corrode due to the action of the higher strength acid. This can happen in stationary applications because the battery never moves to mix the acid. Because our electrolyte is a thick-consistency gel, this stratification cannot happen.

How does a battery recharge?

This process is the same for all types of batteries: liquid, gelled or absorbed/starved electrolyte types.

The chemical actions that take place within a battery during charging are basically the reverse of those that occur during discharge. When a battery is charged, the lead sulfate ($PbSO_4$) in both plates is split into its original form of lead (Pb) and sulfate (SO_4). The water is split into hydrogen (H) and oxygen (O). As the sulfate leaves the plates, it combines with the hydrogen and is restored to sulfuric acid (H_2SO_4). At the same time, the oxygen combines chemically with the lead of the positive plate to form lead dioxide (PbO_2). The specific gravity of the electrolyte increases during charging because sulfuric acid is being formed, replacing water in the electrolyte.

Any lead-acid battery will evolve gas while it is being charged. Hydrogen is given off at the negative plate and oxygen at the positive. These gases result from the decomposition of water (H_2O). A battery gasses and uses water because it is being charged at a higher rate than it can accept. This event may happen if the battery is already fully charged, if its plates are sulfated and cannot accept the charge, or if it is too cold to accept a charge.

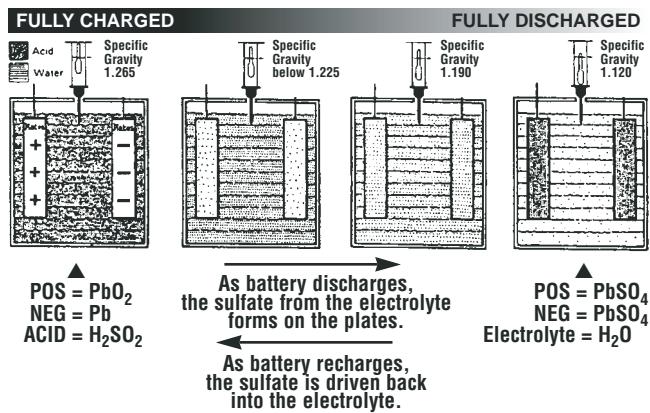
A battery will gas near the end of a charge because the charge rate is too high for the battery to accept. A temperature-compensating, voltage-regulating charger, which automatically reduces the charge rate as the battery approaches the fully charged state, eliminates most of this gassing. **It is extremely important not to charge batteries for long periods of time at rates which**

cause them to gas because they use water, which in sealed valve regulated batteries cannot be replaced. Of course, no battery should be overcharged for a long period of time...even at low rates using so-called "trickle charges."

In a fully charged battery, most of the sulfate is in the sulfuric acid. As the battery discharges, some of the sulfate begins to form on the plates as lead sulfate ($PbSO_4$). As this happens, the acid becomes more dilute, and its specific gravity drops as water replaces more of the sulfuric acid. A fully discharged battery has more sulfate in the plates than in the electrolyte.

Illustrated below is the relationship between specific gravity readings and the combination of the sulfate from the acid with the positive and negative plates at various states of charge.

Typical "Flooded" Battery



How critical is recharge voltage? Why are SVR batteries so charge sensitive?

SVR (Sealed Valve Regulated) batteries work on the **recombination principle**. This means that during charging, the hydrogen produced on the negative plate and oxygen produced on the positive* are recombined to produce H_2O , or water. Water replaces the moisture in the gel or in the absorbed mat separators.

* All lead-acid batteries give off hydrogen from the negative plate and oxygen from the positive plate during charging.

SVR batteries have special pressure-sensitive valves to keep the cell at a specified internal pressure. This pressure is necessary for the recombination of hydrogen and oxygen to work properly. Without pressure, the hydrogen and oxygen would be lost to the atmosphere, eventually drying out the gel or absorbed separators.

Remember that voltage is electrical pressure and current (amps) is electrical flow. Battery plates can be subjected to too much charge (overcharging). If a battery's plates are subjected to too much electrical pressure (excessive on-charge voltage), they will give off more hydrogen and oxygen than can be recombined.

The excess gas raises the pressure in the battery which is vented outside through the safety pressure release valves. When this gas is released, hydrogen and oxygen are lost and cannot be replaced. With excessive charging, any SVR battery will dry out and fail prematurely.

Therefore, **charging must be carefully regulated**:

13.8–14.1V for gel cells.

14.4–14.6V for SAT absorbed-electrolyte models.

A reliable, automatic temperature-sensing, voltage compensating charger must be used. NEVER leave any battery on a "trickle charger."

How long does it take to recharge a fully discharged gel battery?

A specific time is difficult to determine because recharging depends on so many variables:

- Depth of discharge
- Temperature
- Size and efficiency of the charger
- Age and condition of the battery

See the Gel Cell Charging Guide on page 13 for an estimated time based upon the initial charge current the battery accepts.

Charging Time vs. 90% and 100% State of Charge



It will take about 60% of the time to bring the battery from 10.5 volts to 90% of charge (12.75 volts). It will take the remaining 40% of the charging time to put the last 10% of the charge into the battery (12.95 volts = 100% charge).

Gel Cell Charging Guide

Charge Time vs.

Initial Charge Current to 90% Full Charge

(Using an automatic temperature-sensing, voltage-regulating charger set at 13.8V. Totally discharged battery at 11.80-12.0 volts.)

Part No.	Initial Amps	13 hours*	6 Hours*	3½ hours*
8GU1, 8GU1H	3	8	15	
8G22NF	5	12	23	
8G24	7	17	33	
8G27	8	21	41	
8G30H, 8G31, 8G31DT	9	24	45	
8G4D, 8GGC2	17	42	83	
8G8D	20	50	100	

*approximate

HOW TO USE THIS CHART: When charger is first turned on, read amps after about one minute. Initial amp reading will indicate approximate charging time.

EXAMPLE

If an 8G24 reads about 17 amps charge current when first turned on, the battery will be at 90% in about 6 hours.

IMPORTANT: Always use an automatic temperature-sensing, voltage-regulated charger! Set charger at 13.8 to 14.1 volts at 68°F. Do not exceed 14.1 volts! Never open a sealed gel battery!

How can continual undercharging harm a battery?

In many respects, **undercharging is as harmful as overcharging**. Keeping a battery in an undercharged condition allows the positive grids to corrode and the plates to shed, dramatically shortening life. Also, an undercharged battery must work harder than a fully charged battery, which contributes to short life as well.

How can you tell if an SVR battery is fully charged?

The only way is with a voltmeter.

Open Circuit Voltage vs. State of Charge Comparison*

Charge %	Open Circuit Voltage		
	Flooded	Gel	Absorbed
100	12.70-12.60	12.95-12.85	12.90-12.80
75	12.40	12.65	12.60
50	12.20	12.35	12.30
25	12.00	12.00	12.00
0	11.80	11.80	11.80

NOTE: Divide values in half for 6-volt batteries.

* The "true" O.C.V. of a battery can only be determined after the battery has been removed from the load (charge or discharge) for 24 hours.

How can you tell if an SVR battery has been damaged by under- or overcharging?

The only way is **with a load test**. Use the same procedure you would use with a wet cell battery:

- a. Recharge if the open circuit voltage is below 75%.
- b. If adjustable, set the load at ½ the CCA rating or three times the 20 Ah rate.
- c. Apply the load for 15 seconds. The voltage should stabilize above 9.6 volts while on load.
- d. If below 9.6 volts, recharge and repeat test.
- e. If below 9.6 volts a second time, recycle the battery.

What is a float charger?

What float voltage is recommended?

A float charger is sometimes called a "smart" charger. This type of charger continually delivers a pre-set voltage to the battery, regardless of charge conditions.

When the charger senses that the voltage has dropped below the designated setting (the float voltage), **the charger automatically turns on**. It charges the battery until it comes back up to the proper voltage, and then shuts off...or nearly off. Some keep a few milliamps of current flowing to the battery, **which may be a problem if this current is too high**.

These chargers are used in stationary, emergency back-up power, emergency lighting, and other applications.

The frequency of discharge and temperature will dictate a more exact setting. For example, the more frequent the discharge, the higher the suggested recharge voltage, to a **maximum of 2.35 volts per cell (at 20°C/68°F)**.

Our recommended float voltage is 2.25 to 2.3 volts per cell for gel and absorbed models.

How do I know if a charger is "gel friendly?"

Unfortunately, some chargers are falsely called "automatic, temperature-sensing, adjustable voltage." In addition, a charger may be old, out of adjustment, or in need of repair.

Rule #1 : Only charge gel cells using a reliable, automatic, temperature-sensing, voltage-regulated charger. Never use a constant current charger. (Constant current charging will overcharge any SVR battery.)

Always keep charging current in the range of 13.8V to 14.1V for 12-volt gel models (6.90 to 7.05 for 6-volt gel).

Always keep charging current in the range of 14.4V to 14.6V for 12-volt absorbed models (7.2 to 7.3 for 6-volt gel).

If you are not sure if a charger is performing properly, follow this procedure:

- a. Using a fully discharged gel cell battery (11.8V to 10.5V) and a digital voltmeter, record the initial open circuit voltage at the battery terminals.
- b. Using an automatic charger as described above, set voltage if adjustable (14.1V for gel, 14.6V for absorbed models).
- c. Connect and start charging. Record initial on-charge voltage and current (amps).
- d. Using the Gel Cell Charging Guide on page 13, estimate the time required to bring to full charge, based on the initial charging current noted in "c" above.
- e. Each hour or so, check and record the on-charge voltage across the battery terminals. Except for occasional, brief "blips" or pulses, the voltage should not exceed the voltage limits noted in "b" above.
- f. At the end of charge (when the current is very low or goes to zero) check and record the voltage. Note that the charger may have turned off by then.
- g. The disconnected battery should be at 100% or above (due to "surface charge").

During the charging time, the charger should not have exceeded the limit (except for occasional, brief pulses). This indicates that the charger is working properly.

Keep in mind that the voltage limit is at 68°F/20°C. Charging at higher or lower temperatures will change this limit. (See the chart on page 11: Effect of Temperature on Recharge Voltage.) A temperature-sensing charger should always be used, as manual adjustments are never accurate and will damage any SVR battery.

Do gel cell batteries have a "memory" like ni-cad batteries?

One of the major disadvantages of nickel-cadmium, or ni-cad, batteries is that when they are only partially charged after several uses, they "remember" the charge limit and will not allow recharging back to 100%, unless totally discharged and recharged several times. Our gel cells have no such memory.

What is a safe charge rate or voltage setting for outdoor applications with wide temperature fluctuations if a temperature-sensing charger is not available?

NONE! As the chart on page 11 (Effect of Temperature on Recharge Voltage) shows, charging voltage varies widely with temperature. **There is no fixed voltage setting or current that will work.** A temperature-sensing, voltage-regulated charger must be used. Anything else will damage the battery and **cause premature failure!**

Can an SVR battery be load tested the same as a flooded battery?

Yes. See page 13 (How can you tell if an SVR battery has been damaged by under- or overcharging?).

Why do some gel batteries bulge? Are there visual signs of a faulty or plugged pressure relief valve?

In order to operate properly and for the recombination of hydrogen and oxygen to take place, each cell is pressurized under approximately 1½ psi.

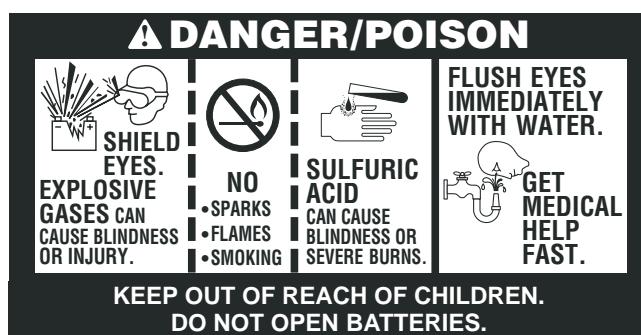
Batteries with very large cells, such as the 8G4D and 8G8D, will bulge somewhat as this normal pressure builds. This is especially true in higher temperatures, because the polypropylene case is more pliable. Therefore, **a certain amount of bulge is normal.**

However, if a battery bulges severely, such as to look like a football, this is not normal and is an indication of a blocked valve. Such a battery should be taken out of service.

How safe are SVR batteries? Can they explode?

SVR batteries are very safe, unless abused. However, as with any type battery, certain safety precautions must be taken.

ALWAYS WEAR SAFETY GLASSES WHEN WORKING AROUND BATTERIES!



Because SVR batteries normally emit very little to no hydrogen gas, they are safe near sensitive electronic equipment. They do not cause corrosion of surrounding metals. No hydrogen gas means no dangerous explosions... **UNLESS SEVERELY OVERCHARGED!**

Do not install any lead-acid battery in a sealed container or enclosure. Hydrogen gas from overcharging must be allowed to escape.

DO NOT CHARGE IN EXCESS OF 14.1V @ 68°F- Gel Cells
DO NOT CHARGE IN EXCESS OF 14.6V @ 68°F- Absorbed

(See Voltage vs. Temperature Chart on page 11.)

Always use a reliable, temperature-sensing, voltage-regulated, automatic charger.

Because SVR batteries have immobilized electrolyte, they cannot spill or leak, even if punctured. That is why they are approved for air transport by the International Commercial Airline Organization (ICAO), International Airline Transport Association (IATA), and Department of Transportation (DOT) as noted on the label.

Also, when protected against short circuits and securely braced/ blocked, our gel cell batteries "are not subject to any other requirements of 49 CFR Parts 171-180..." for shipping.

Which way does current flow? On which side should a circuit breaker be installed?

Contrary to popular belief, **current flows from the negative electrode, through the load and back to the positive electrode**. Therefore, a fuse or circuit breaker is best installed between the negative post and the load. This also works well because the positive cable generally has several leads or taps connected to it.

What do I need to know about installation, especially in salt water marine applications?

Wiring and Waterproofing

ALWAYS WEAR SAFETY GLASSES WHEN WORKING AROUND BATTERIES!

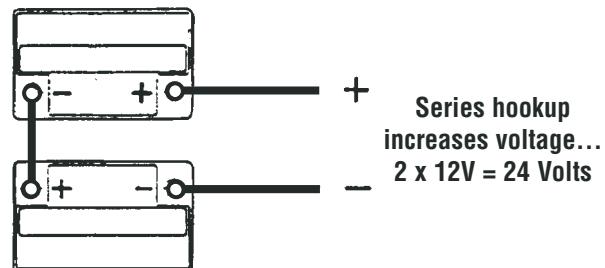
- a. Cabling of the approved gauge should be tinned copper. If using untinned copper, allow plenty of spray silicone to "wick" along the strands.
- b. Install heat-shrink tubing with a silicone interior; the silicone forms an excellent moisture barrier. Cut the tubing long enough to cover the terminal lug and plenty of the insulated portion of the cable. Slip tubing onto the cable.
- c. Crimp on the appropriate terminal.
- d. Position the heat-shrink tubing. Heat and inspect.
- e. Clean battery terminals and connect. Be sure perfect metal-to-metal contact is made, with no dirt, corrosion, grease or foreign material to interfere with current flow.
- f. Always attach the cable connected to the solenoid or starter first. Attach the ground cable last! Tighten snugly, BUT DO NOT OVERTIGHTEN, which will damage the terminals or crack the battery cover. This will destroy the battery and VOID THE WARRANTY.
- g. Spray exposed terminals and connectors with several coats of battery terminal corrosion protection spray. (Mask surrounding areas to protect against overspray.)
- h. For batteries which may be exposed to very wet environments (e.g. bilge mounted batteries) total encasement of the exposed terminals and connectors is necessary. However, do not block or cover the vents.

A battery terminal boot should be used. Install the boot on the cable before crimping the terminal. Fill the boot with petroleum jelly and fit over the sprayed connectors (as in "g" above).

Battery Installation

Series

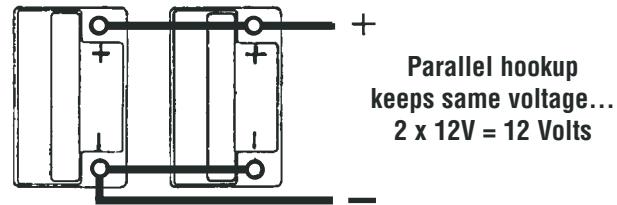
A "series" system increases the voltage, but keeps the battery capacity (cranking amps, amp hours, reserve minutes, and minutes running time) the same. Therefore, two 12-volt batteries connected in series (POS to NEG, NEG to POS) will deliver 24 volts at the same rating as one battery:



During recharge, each battery receives the same amount of current; e.g. if the charger is putting out 10 amps, both batteries are getting 10 amps.

Parallel

A "parallel" system increases the capacity available, but keeps the voltage the same. Therefore, two 12-volt batteries with 400 CCA, 110 R.C. and 65 Ah will deliver 12 volts, 800 CCA, 220 R.C. and 130 Ah.



During recharge, the current (amps) is split between the batteries. The battery that is discharged the most will receive more current than the other until both are brought up to full charge.

Note: Never mix different types and sizes of batteries in the same bank.

To properly recharge, a sophisticated "battery isolator" should be installed. Otherwise, one battery will be continually overcharged and the other undercharged in a series/parallel set-up.

IMPORTANT: Do not install any type of battery in a completely sealed box or enclosure. In the event of overcharging, the potentially explosive gasses must be allowed to escape.



QUALITY SYSTEM
CERTIFIED TO
ISO 9001

NOTES



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